

1. A homogenous charge compression ignition barrel engine comprising:
2 An engine housing having a first end and a second end;
a elongated power shaft longitudinally disposed in the engine housing and
4 defining a longitudinal axis of the engine;
a plurality of cylinders surrounding the longitudinal axis, each cylinder having a
6 closed end and an open end, each cylinder having a central axis, the open ends of the
cylinders each being generally directed toward the first end of the housing;
8 an intake system operable to introduce a combustible mixture of air and fuel into
each of the cylinders;
10 a track disposed between the first end of the housing and the open ends of the
cylinders such that a portion of the track is disposed generally in alignment with the
12 central axis of each of the cylinders, the track having a cam surface that longitudinally
undulates with respect to the open ends of the cylinders, a portion of the cam surface
14 being disposed generally in alignment with the central axis of each of the cylinders, the
track and the cylinders being rotatable with respect to each other such that the undulating
16 cam surface moves with respect to the open ends of the cylinders; and
a piston movably disposed in each of the cylinders such that a combustion
18 chamber is defined between the piston and the closed end of the cylinder, each piston
being in mechanical communication with the cam surface of the track such that as the
20 cylinders and track move with respect to each other, the pistons reciprocate within the
cylinders, each piston being operable to compress the combustible mixture until the
22 mixture autoignites, without the introduction of a spark.

2. The engine according to claim 1, further comprising a variable
2 compression ratio device operable to adjust the longitudinal position of the track with
respect to the open ends of the cylinders such that the compression ratio of the engine is
4 adjusted.

2 3. The engine according to claim 1, wherein the central axis of each of the
cylinders is parallel to the longitudinal axis of the engine.

2 4. The engine according to claim 1, wherein the track is disposed generally
in a plane that is perpendicular to the longitudinal axis of the engine and the cam surface
is disposed at a generally constant distance from the longitudinal axis of the engine.

2 5. The engine according to claim 1, wherein the track is in mechanical
communication with the power shaft such that the shaft and track rotate in unison with
respect to the cylinders.

2 6. The engine according to claim 1, wherein the track is in mechanical
communication with the engine housing such that the track and the engine housing do not
rotate with respect to each other, the cylinders and the power shaft being in mechanical
4 communication such that the cylinders and power shaft rotate in unison with respect to
the engine housing.

2 7. The engine according to claim 1, further comprising a water injection
system operable to selectively introduce water into the cylinders, to thereby alter the
combustion phasing for the cylinders.

2 8. The engine according to claim 7, wherein the water injection system
comprises discrete water injectors for selectively introducing different amounts of water
into different ones of the cylinders, to thereby alter the relative combustion phasing of the
4 different ones of the cylinders.

2 9. The engine according to claim 1, wherein the undulating cam surface
defines a generally sinusoidal shape.

10. The engine according to claim 1, wherein the undulating cam surface
2 defines a non-sinusoidal shape.

11. The engine according to claim 10, wherein the cam surface includes at
2 least one top dead center portion, the top dead center portion being linearly shorter than if
the cam surface defined a sinusoidal shape.

12. The engine according to claim 10, wherein the cam surface defines at least
2 one compression stroke and one expansion stroke, the compression stroke being slower
and the expansion stroke being faster than if the cam surface defined a sinusoidal shape.

13. The engine according to claim 1, wherein the intake system includes
2 intake and exhaust valves operable to open and close to controllably allow intake and
exhaust to enter and exit the cylinders, the opening and closing time of the intake valves
4 and the exhaust valves being controllably adjustable with respect to the rotational
position of the track with respect to the cylinders.

14. The engine according to claim 1, further comprising:
2 a second plurality of cylinders disposed between the track and the first end of the
housing, each of the cylinders having a closed end and an open end, the open ends of the
4 cylinders each being generally directed toward the second end of the housing; and
a piston movably disposed in each of the second plurality of cylinders such that a
6 combustion chamber is defined between the piston and the closed end of the cylinder,
each piston being in mechanical communication with the cam surface of the track such
8 that as the cylinders and track move with respect to each other, the pistons reciprocate
within the cylinders.

15. The engine according to claim 14, wherein the second plurality of
2 cylinders and the pistons therein comprise a supercharger for compressing air to be used
for the combustible mixture.

16. The engine according to claim 14, further comprising an intake system
2 operable to introduce a combustible mixture of air and fuel into each of the cylinders in
the second plurality, and wherein each piston disposed in the second plurality of cylinders
4 is operable to compress the combustible mixture until the mixture autoignites, without the
introduction of a spark.

17. A method of converting fuel and air into rotational energy comprising the
2 steps of:

providing a homogenous charge compression ignition barrel engine comprising:

4 an engine housing having a first end and a second end;

a elongated power shaft longitudinally disposed in the engine housing and
6 defining a longitudinal axis of the engine;

a plurality of cylinders surrounding the longitudinal axis, each cylinder
8 having a closed end and an open end, each cylinder having a central axis, the open ends
of the cylinders each being generally directed toward the first end of the housing;

10 a track disposed between the first end of the housing and the open ends of
the cylinders such that a portion of the track is disposed generally in alignment with the
12 central axis of each of the cylinders, the track having a cam surface that longitudinally
undulates with respect to the open ends of the cylinders, a portion of the cam surface
14 being disposed generally in alignment with the central axis of each of the cylinders, the
track and the cylinders being rotatable with respect to each other such that the undulating
16 cam surface moves with respect to the open ends of the cylinders; and

a piston movably disposed in each of the cylinders such that a combustion
18 chamber is defined between the piston and the closed end of the cylinder, each piston
being in mechanical communication with the cam surface of the track such that as the

20 cylinders and track move with respect to each other, the pistons reciprocate within the
cylinders between an upper position and a lower position;
22 rotating the track so as to position one of the pistons in the upper position;
continuing to rotate the track such that the one piston moves between the upper
24 position and the lower position;
introducing a combustible mixture of air and fuel into the combustion chamber as
26 the piston moves between the upper and the lower position;
continuing to rotate the track such that the one piston moves between the lower
28 position and the upper position and the combustible mixture is compressed;
compressing the combustible mixture until the mixture autoignites without the
30 introduction of a spark, such that the mixture combusts; and
using the combustion of the mixture to move the piston between the upper
32 position and the lower position, thereby causing the track to rotate.

18. A variable compression ratio homogenous charge compression ignition
2 barrel engine comprising:
an engine housing having a first end and a second end;
4 a elongated power shaft longitudinally disposed in the engine housing and
defining a longitudinal axis of the engine;
6 a plurality of cylinders surrounding the longitudinal axis, each cylinder having a
closed end and an open end, each cylinder having a central axis, the open ends of the
8 cylinders each being generally directed toward the first end of the housing;
an intake system operable to introduce a combustible mixture of air and fuel into
10 each of the cylinders;
a track disposed between the first end of the housing and the open ends of the
12 cylinders such that a portion of the track is disposed generally in alignment with the
central axis of each of the cylinders, the track having a cam surface that longitudinally
14 undulates with respect to the open ends of the cylinders, a portion of the cam surface
being disposed generally in alignment with the central axis of each of the cylinders, the

16 track and the cylinders being rotatable with respect to each other such that the undulating
cam surface moves with respect to the open ends of the cylinders;

18 a piston movably disposed in each of the cylinders such that a combustion
chamber is defined between the piston and the closed end of the cylinder, each piston
20 being in mechanical communication with the cam surface of the track such that as the
cylinders and track move with respect to each other, the pistons reciprocate within the
22 cylinders, each piston being operable to compress the combustible mixture until the
mixture autoignites, without the introduction of a spark; and

24 a variable compression ratio device operable to adjust the longitudinal position of
the track with respect to the open ends of the cylinders such that the compression ratio of
26 the engine is adjusted.

19. The engine according to claim 18, wherein the central axis of each of the
2 cylinders is parallel to the longitudinal axis of the engine.

20. The engine according to claim 18, wherein the track is disposed generally
2 in a plane that is perpendicular to the longitudinal axis of the engine and the cam surface
is disposed at a generally constant distance from the longitudinal axis of the engine.

21. The engine according to claim 18, wherein the track is in mechanical
2 communication with the power shaft such that the shaft and track rotate in unison with
respect to the cylinders.

22. The engine according to claim 18, wherein the track is in mechanical
2 communication with the engine housing such that the track and the engine housing do not
rotate with respect to each other, the cylinders and the power shaft being in mechanical
4 communication such that the cylinders and power shaft rotate in unison with respect to
the engine housing.

23. The engine according to claim 18, further comprising a water injection
2 system operable to selectively introduce water into the cylinders, to thereby alter the
combustion phasing for the cylinders.

24. The engine according to claim 23, wherein the water injection system
2 comprises discrete water injectors for selectively introducing different amounts of water
into different ones of the cylinders, to thereby alter the relative combustion phasing of the
4 different ones of the cylinders.

25. The engine according to claim 18, wherein the undulating cam surface
2 defines a generally sinusoidal shape.

26. The engine according to claim 18, wherein the undulating cam surface
2 defines a non-sinusoidal shape.

27. The engine according to claim 26, wherein the cam surface includes at
2 least one top dead center portion, the top dead center portion being linearly shorter than if
the cam surface defined a sinusoidal shape.

28. The engine according to claim 26, wherein the cam surface defines at least
2 one compression stroke and one expansion stroke, the compression stroke being slower
and the expansion slope being faster than if the cam surface defined a sinusoidal shape.

29. The engine according to claim 18, wherein the intake system includes
2 intake and exhaust valves operable to open and close to controllably allow intake and
exhaust to enter and exit the cylinders, the opening and closing time of the intake valves
4 and the exhaust valves being controllably adjustable with respect to the rotational
position of the track with respect to the cylinders.

30. A method of converting fuel and air into rotational energy comprising the
2 steps of:
providing a variable compression ratio homogenous charge compression ignition
4 barrel engine comprising:
an engine housing having a first end and a second end;
6 a elongated power shaft longitudinally disposed in the engine housing and
defining a longitudinal axis of the engine;
8 a plurality of cylinders surrounding the longitudinal axis, each cylinder
having a closed end and an open end, each cylinder having a central axis, the open ends
10 of the cylinders each being generally directed toward the first end of the housing;
a track disposed between the first end of the housing and the open ends of
12 the cylinders such that a portion of the track is disposed generally in alignment with the
central axis of each of the cylinders, the track having a cam surface that longitudinally
14 undulates with respect to the open ends of the cylinders, a portion of the cam surface
being disposed generally in alignment with the central axis of each of the cylinders, the
16 track and the cylinders being rotatable with respect to each other such that the undulating
cam surface moves with respect to the open ends of the cylinders;
18 a piston movably disposed in each of the cylinders such that a combustion
chamber is defined between the piston and the closed end of the cylinder, each piston
20 being in mechanical communication with the cam surface of the track such that as the
cylinders and track move with respect to each other, the pistons reciprocate within the
22 cylinders between an upper position and a lower position; and
a variable compression ratio device operable to adjust the longitudinal
24 position of the track with respect to the open ends of the cylinders such that the
compression ratio of the engine is adjusted
26 rotating the track so as to position one of the pistons in the upper position;
continuing to rotate the track such that the one piston moves between the upper
28 position and the lower position;

introducing a combustible mixture of air and fuel into the combustion chamber as
30 the piston moves between the upper and the lower position;
continuing to rotate the track such that the one piston moves between the lower
32 position and the upper position and the combustible mixture is compressed; and
adjusting the compression ratio until the compression of the combustible mixture
34 is sufficient to cause the mixture to autoignite without the introduction of a spark, such
that the mixture combusts; and
36 using the combustion of the mixture to move the piston between the upper
position and the lower position, thereby causing the track to rotate.

31. The method according to 30, further comprising:
2 continuing rotating the track and repeating the introducing step; and
adjusting the compression ratio so as to generally avoid combustion prior to the
4 piston reaching the upper position.

32. A corona discharge device for an internal combustion engine, the device
2 comprising:
a corona discharge element configured to be disposed in the intake system of an
4 internal combustion engine, the corona discharge element being operable when energized
and disposed in air to ionize some of the gases in the air and to create free radicals.

33. An internal combustion engine with a corona discharge device,
2 comprising:
an engine housing;
4 a combustion chamber defined in the housing;
an intake system operable to introduce air into the combustion chamber;
6 a corona discharge device disposed in the intake system, the corona discharge
device operable to ionize gasses in the intake system and to create free radicals.

2 34. A method of adjusting mixture reactivity of a mixture in a combustion
3 chamber in an internal combustion engine, comprising the steps of:
4 providing a corona discharge device operable to ionize gases and create free
5 radicals when energized and disposed in the gases;
6 disposing the corona discharge device in air;
7 energizing the corona discharge device so as to ionize some of the gases in the air
8 and to create free radicals; and
9 introducing some of the ionized gases and free radicals into the combustion
10 chamber so as to adjust the mixture reactivity of the mixture in the combustion chamber.

11 35. A homogenous charge compression ignition barrel engine comprising:
12 an engine housing having a first end and a second end;
13 a elongated power shaft longitudinally disposed in the engine housing and
14 defining a longitudinal axis of the engine;
15 a plurality of cylinders surrounding the longitudinal axis, each cylinder having a
16 closed end and an open end, each cylinder having a central axis, the open ends of the
17 cylinders each being generally directed toward the first end of the housing;
18 an intake system operable to introduce a combustible mixture of air and fuel into
19 each of the cylinders;
20 a corona discharge device operable to selectively create free radicals and ionize
21 some of the air or the combustible mixture introduced into the cylinders so as to adjust
22 the reactivity of the combustible mixture;
23 a track disposed between the first end of the housing and the open ends of the
24 cylinders such that a portion of the track is disposed generally in alignment with the
25 central axis of each of the cylinders, the track having a cam surface that longitudinally
26 undulates with respect to the open ends of the cylinders, a portion of the cam surface
27 being disposed generally in alignment with the central axis of each of the cylinders, the
28 track and the cylinders being rotatable with respect to each other such that the undulating
29 cam surface moves with respect to the open ends of the cylinders; and

20 a piston movably disposed in each of the cylinders such that a combustion
chamber is defined between the piston and the closed end of the cylinder, each piston
22 being in mechanical communication with the cam surface of the track such that as the
cylinders and track move with respect to each other, the pistons reciprocate within the
24 cylinders, each piston being operable to compress the combustible mixture until the
mixture autoignites, without the introduction of a spark

36. The engine according to claim 35, wherein the corona discharge device is
2 disposed in the intake system.

37. The engine according to claim 35, wherein the corona discharge device is
2 disposed in at least one of the cylinders.

38. A method of controlling combustion phasing in a homogenous charge
2 compression engine, comprising the steps of:
 providing a homogenous charge compression engine of the type operable to
4 compress a combustible mixture of fuel and air until the mixture autoignites without the
introduction of a spark, the engine having at least one combustion chamber;
6 providing a corona discharge device operable to create free radicals and ionize
gases when energized and disposed in the gases;
8 disposing the corona discharge in air;
 selectively energizing the corona discharge device to create free radicals and
10 ionize some of the gases in the air;
 introducing some of the free radicals and ionized gases into the combustible
12 mixture so as to alter the mixture reactivity of the combustible mixture and to adjust the
combustion phasing of the engine; and
14 adjusting the energizing of the corona discharge device so as to control
combustion phasing in the engine.

2 39. The method according to claim 39, wherein the engine includes an intake
system operable to introduce the combustible mixture, the corona discharge device being
disposed in the intake system.

2 40. The method according to claim 38, wherein the disposing step comprises
disposing the corona discharge device in the combustible mixture of air and fuel.

2 41. A homogenous charge compression ignition barrel engine comprising:
an engine housing having a first end and a second end;
a elongated power shaft longitudinally disposed in the engine housing and
4 defining a longitudinal axis of the engine;
a plurality of cylinders surrounding the longitudinal axis, each cylinder having a
6 closed end and an open end, each cylinder having a central axis, the open ends of the
cylinders each being generally directed toward the first end of the housing;
8 an intake system operable to introduce a combustible mixture of air and fuel into
each of the cylinders;
10 a track disposed between the first end of the housing and the open ends of the
cylinders such that a portion of the track is disposed generally in alignment with the
12 central axis of each of the cylinders, the track having a cam surface that longitudinally
undulates with respect to the open ends of the cylinders, a portion of the cam surface
14 being disposed generally in alignment with the central axis of each of the cylinders, the
track and the cylinders being rotatable with respect to each other such that the undulating
16 cam surface moves with respect to the open ends of the cylinders;
a piston movably disposed in each of the cylinders such that a combustion
18 chamber is defined between the piston and the closed end of the cylinder, each piston
being in mechanical communication with the cam surface of the track such that as the
20 cylinders and track move with respect to each other, the pistons reciprocate within the
cylinders, each piston being operable to compress the combustible mixture; and

22 a rapid compression device operable to rapidly increase the compression level in
one of the combustion chambers after the piston has at least partially compressed the
24 mixture and to cause the combustible mixture to autoignite without the introduction of a
spark.

42. The engine according to claim 41, wherein the rapid compression device
2 comprises a movable member operable to change the volume of the combustion chamber.

43. The engine according to claim 42, wherein the movable member is a
2 secondary piston disposed in the closed upper end of the cylinder.

44. The engine according to claim 41, wherein the rapid compression device
2 comprises:

 a body having a secondary chamber defined therein with an opening
4 communicating between the secondary chamber and the combustion chamber;

 an ignition device operable to ignite a combustible mixture in the secondary
6 chamber; and

 a gas permeable spark arrestor disposed in the opening such that an ignited
8 combustible mixture in the chamber is extinguished as the mixture is forced through the
arrestor.

45. The engine according to claim 44, wherein the ignition device is a spark
2 plug.

46. The engine according to claim 44, wherein the rapid compression device
2 comprises:

 a system operable to inject hot gas into the combustion chamber.

47. The engine according to claim 41, wherein the rapid compression device
2 comprises:

4 a system operable to capture a portion of the combustion product created by the
first autoignition of the combustible mixture and to release the captured portion into a
subsequent compressed combustible mixture to cause autoignition.

48. A rapid compression device for introducing a charge of hot gas into a
2 combustion chamber in an internal combustion engine, the rapid compression device
comprising:

4 a body having a chamber defined therein with an opening communicating with the
chamber;

6 an ignition device operable to ignite a combustible mixture in the secondary
chamber; and

8 a gas permeable spark arrestor disposed in the opening of the chamber such that
an ignited combustible mixture in the chamber is extinguished as the mixture is forced
10 through the arrestor.

49. An internal combustion engine comprising:

2 a main combustion chamber having an opening defined therein;

4 a secondary combustion chamber in gaseous communication with the opening in
the main combustion chamber;

6 a ignition device in communication with the secondary combustion chamber for
igniting a combustible mixture therein; and

8 a spark arrestor disposed in the opening in the main combustion chamber, the
spark arrestor operable to pass gases therethrough and to extinguish combustion in the
gases passed through the opening.

50. A method of introducing a charge of hot gas into a combustion chamber of
2 an internal combustion engine, the method comprising the steps of:

providing an internal combustion engine having a combustion chamber defined
4 therein;
providing a secondary chamber in gaseous communication with the combustion
6 chamber;
introducing a combustible mixture of air and fuel into the secondary chamber;
8 combusting the mixture of air and fuel in the secondary chamber so as to produce
a hot gaseous combustion product;
10 passing the combustion product from the secondary chamber to the combustion
chamber; and
12 extinguishing the combustion product so as to create a hot gas as the combustion
product passes from the secondary chamber to the combustion chamber;
14 whereby a hot gas is introduced into the combustion chamber.

51. The method according to claim 50, further comprising:
2 providing a spark ignition device in the secondary chamber, the device operable
to introduce a spark into the secondary chamber; and
4 the combusting comprising introducing a spark from the spark ignition device to
combust the mixture.

52. The method according to claim 50, further comprising:
2 providing a flame arrestor and the extinguishing step comprising passing the
combustion product through the flame arrestor.

53. The method according to claim 50, wherein the combusting step
2 comprises compressing the mixture in the secondary chamber until the mixture
autoignites without the introduction of a spark.

54. A method of introducing pressurized gas into a combustion chamber,
2 comprising:

4 providing an internal combustion engine having a combustion chamber;
introducing a mixture of air and fuel into the combustion chamber;
compressing the mixture of air and fuel in the combustion chamber;
6 combusting the mixture of fuel and air in the combustion chamber to create a
pressurized gaseous combustion product;
8 capturing and holding a portion of the pressurized gaseous combustion product;
exhausting substantially all of the remainder of the gaseous combustion product
10 out of the combustion chamber;
introducing a fresh mixture of air and fuel into the combustion chamber;
12 compressing the fresh mixture in the combustion chamber; and
releasing at least some of the held portion of the pressurized gaseous combustion
14 product into compressed fresh mixture in the combustion chamber.

55. An internal combustion engine utilizing an HCCI combustion strategy, the
2 engine comprising:
an engine housing
4 a first and a second cylinder defined in the engine housing;
an intake system operable to introduce a combustible mixture of air and fuel into
6 the cylinders;
a first piston disposed in the first cylinder operable to compress the combustible
8 mixture in the first cylinder until the mixture autoignites without the introduction of a
spark;
10 a second piston disposed in the second cylinder operable to compress the
combustible mixture in the second cylinder until the mixture autoignites without the
12 introduction of a spark;
a first corona discharge device selectively operable to introduce ions and free
14 radicals into the combustible mixture introduced into the first cylinder, thereby altering
the mixture reactivity of the combustible mixture in the first cylinder and the combustion
16 phasing for the first cylinder;

18 a second corona discharge device selectively operable to introduce ions and free
radicals into the combustible mixture introduced into the second cylinder, thereby
altering the mixture reactivity of the combustible mixture in the second cylinder and the
20 combustion phasing for the second cylinder; and

a controller operable to control the first and second corona discharge devices so as
22 to selectively adjust the relative combustion phasing of the first and second cylinders.

56. The engine according to claim 55, wherein the intake system includes a
2 first runner for introducing the mixture into the first cylinder and a second runner for
introducing the mixture into the second cylinder, the first corona discharge device being
4 disposed in the first runner and the second corona discharge device being disposed in the
second cylinder.

57. A method of controlling a homogenous charge compression ignition
2 engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

4 an engine housing

a first and a second cylinder defined in the engine housing;

6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders;

8 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
10 introduction of a spark;

a second piston disposed in the second cylinder operable to compress the
12 combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark;

14 selectively introducing ions and free radicals into the combustible mixture in the
first cylinder so as to adjust the mixture reactivity of the combustible mixture and the
16 combustion phasing for the first cylinder;

selectively introducing ions and free radicals into the combustible mixture in the
18 second cylinder so as to adjust the mixture reactivity of the combustible mixture and the
combustion phasing for the second cylinder;

20 controlling the introduction of ions and free radicals to the first and second
cylinders so as to selectively adjust the relative combustion phasing of the first and
22 second cylinders.

58. An internal combustion engine utilizing an HCCI combustion strategy, the
2 engine comprising:

an engine housing

4 a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into
6 the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible
8 mixture in the first cylinder until the mixture autoignites without the introduction of a
spark;

10 a second piston disposed in the second cylinder operable to compress the
combustible mixture in the second cylinder until the mixture autoignites without the
12 introduction of a spark;

a first water injector operable to selectively introduce water into the first cylinder,
14 thereby altering the combustion phasing for the first cylinder;

a second water injector operable to selectively introduce water into the second
16 cylinder, thereby altering the combustion phasing for the second cylinder;

a controller operable to control the first and second water injectors so as to
18 selectively adjust the relative combustion phasing of the first and second cylinders.

59. A method of controlling a homogenous charge compression ignition
2 engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

- 4 an engine housing
 a first and a second cylinder defined in the engine housing;
- 6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders;
- 8 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
10 introduction of a spark;
- a second piston disposed in the second cylinder operable to compress the
12 combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark;
- 14 selectively introducing water into the first cylinder so as to adjust the combustion
phasing for the first cylinder;
- 16 selectively introducing water into the second cylinder so as to adjust the
combustion phasing for the second cylinder;
- 18 controlling the introduction of water into the first and second cylinders so as to
selectively adjust the relative combustion phasing of the first and second cylinders.

60. An internal combustion engine utilizing an HCCI combustion strategy, the
2 engine comprising:
- an engine housing
- 4 a first and a second cylinder defined in the engine housing;
 an intake system operable to introduce a combustible mixture of air and fuel into
6 the cylinders;
- a first piston disposed in the first cylinder operable to compress the combustible
8 mixture in the first cylinder until the mixture autoignites without the introduction of a
spark;
- 10 a second piston disposed in the second cylinder operable to compress the
combustible mixture in the second cylinder until the mixture autoignites without the
12 introduction of a spark;

14 a first cooling system operable to selectively cool the first cylinder, thereby
altering the combustion phasing for the first cylinder;
16 a second cooling system operable to selectively cool the second cylinder, thereby
altering the combustion phasing for the second cylinder;
18 a controller operable to control the first and second cooling systems so as to
selectively adjust the relative combustion phasing of the first and second cylinders.

61. The internal combustion engine according to claim 60, wherein:
2 the first cooling system comprises a first coolant supply, first coolant jacket at
least partially surrounding the first cylinder and a first coolant control valve for
4 controlling a flow of coolant from the first coolant supply through the first coolant jacket;
and
6 the second cooling system comprises a second coolant supply, a second coolant
jacket at least partially surrounding the second cylinder and a second coolant control
8 valve for controlling a flow of coolant from the second coolant supply through the second
coolant jacket.

62. A method of controlling a homogenous charge compression ignition
2 engine, comprising:
providing a homogenous charge compression ignition engine, comprising:
4 an engine housing
a first and a second cylinder defined in the engine housing;
6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders;
8 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
10 introduction of a spark;

- 12 a second piston disposed in the second cylinder operable to compress the
combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark;
- 14 selectively cooling the first cylinder so as to adjust the combustion phasing for the
first cylinder;
- 16 selectively cooling the second cylinder so as to adjust the combustion phasing for
the second cylinder;
- 18 controlling the cooling of the first and second cylinders so as to selectively adjust
the relative combustion phasing of the first and second cylinders.

63. An internal combustion engine utilizing an HCCI combustion strategy, the
- 2 engine comprising:
 - an engine housing;
 - 4 a first and a second cylinder defined in the engine housing;
 - an intake system operable to introduce a combustible mixture of air and fuel into
 - 6 the cylinders, the intake system comprising a first fuel injector for providing fuel for the
combustible mixture for the first cylinder and a second fuel injector for providing fuel for
 - 8 the combustible mixture for the second cylinder, the combustible mixture for the first
cylinder having a first air-fuel ratio and the combustible mixture for the second cylinder
 - 10 having a second air-fuel ratio;
 - a first piston disposed in the first cylinder operable to compress the combustible
 - 12 mixture in the first cylinder until the mixture autoignites without the introduction of a
spark;
 - 14 a second piston disposed in the second cylinder operable to compress the
combustible mixture in the second cylinder until the mixture autoignites without the
 - 16 introduction of a spark; and
 - a controller operable to control the first and second fuel injectors so as to
 - 18 selectively adjust the air-fuel ratio for the first and second cylinder to adjust the relative
combustion phasing of the first and second cylinders.

2 64. A method of controlling a homogenous charge compression ignition
engine, comprising:
 providing a homogenous charge compression ignition engine, comprising:
4 an engine housing
 a first and a second cylinder defined in the engine housing;
6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders, the intake system comprising a first fuel injector for providing fuel
8 for the combustible mixture for the first cylinder and a second fuel injector for providing
fuel for the combustible mixture for the second cylinder, the combustible mixture for the
10 first cylinder having a first air-fuel ratio and the combustible mixture for the second
cylinder having a second air-fuel ratio;
12 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
14 introduction of a spark;
 a second piston disposed in the second cylinder operable to compress the
16 combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark;
18 controlling the first and second fuel injectors so as to selectively adjust the air-
fuel ratio for the first and second cylinder to adjust the relative combustion phasing of the
20 first and second cylinders.

2 65. A method of controlling a homogenous charge compression ignition
engine, comprising:
 providing a homogenous charge compression ignition engine, comprising:
4 an engine housing
 a first and a second cylinder defined in the engine housing;
6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders;

8 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
10 introduction of a spark;

 a second piston disposed in the second cylinder operable to compress the
12 combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark; and

14 controlling the temperature of the combustible mixture introduced into the first
and second cylinders so as to adjust the relative combustion phasing of the first and
16 second cylinders.

66. The method according to claim 65, wherein the temperature controlling
2 step comprises selectively warming the air in the combustible mixture.

67. The method according to claim 65, wherein the temperature controlling
2 step comprises selectively mixing warm and cool air for the combustible mixture.

68. A method of controlling a homogenous charge compression ignition
2 engine, comprising:

 providing a homogenous charge compression ignition engine, comprising;
4 an engine housing
 a first and a second cylinder defined in the engine housing;
6 an intake system operable to introduce a combustible mixture of air and
fuel into the cylinders;

8 a first piston disposed in the first cylinder operable to compress the
combustible mixture in the first cylinder until the mixture autoignites without the
10 introduction of a spark;

 a second piston disposed in the second cylinder operable to compress the
12 combustible mixture in the second cylinder until the mixture autoignites without the
introduction of a spark;

14 providing an exhaust gas recirculation system operable to selectively introduce
exhaust gas into the combustible mixture introduced into the first and second cylinders;
16 and
controlling the exhaust gas recirculation system to selectively control how much
18 exhaust gas is introduced into the combustible mixture introduced into the first and
second cylinders so as to adjust the relative combustion phasing of the first and second
20 cylinders.

69. A homogenous charge compression ignition barrel engine comprising:
2 an engine housing having a first end and a second end;
a elongated power shaft longitudinally disposed in the engine housing and
4 defining a longitudinal axis of the engine;
a plurality of cylinders surrounding the longitudinal axis, each cylinder having a
6 first and an opposed second open end, each cylinder having a central axis, the first open
ends of the cylinders each being generally directed toward the first end of the housing
8 and the second open ends being generally directed toward the second end of the housing;
an intake system operable to introduce a combustible mixture of air and fuel into
10 each of the cylinders;
a first track disposed between the first end of the housing and the first open ends
12 of the cylinders such that a portion of the track is disposed generally in alignment with
the central axis of each of the cylinders, the track having a cam surface that longitudinally
14 undulates with respect to the first open ends of the cylinders, a portion of the cam surface
being disposed generally in alignment with the central axis of each of the cylinders, the
16 track and the cylinders being rotatable with respect to each other such that the undulating
cam surface moves with respect to the first open ends of the cylinders;
18 a second track disposed between the second end of the housing and the second
open ends of the cylinders such that a portion of the track is disposed generally in
20 alignment with the central axis of each of the cylinders, the track having a cam surface
that longitudinally undulates with respect to the second open ends of the cylinders, a

22 portion of the cam surface being disposed generally in alignment with the central axis of
each of the cylinders, the track and the cylinders being rotatable with respect to each
24 other such that the undulating cam surface moves with respect to the second open ends of
the cylinders; and
26 a first and a second piston movably disposed in each of the cylinders such that a
combustion chamber is defined between the first and second pistons, each first piston
28 being in mechanical communication with the cam surface of the first track such that as
the cylinders and first track move with respect to each other, the first pistons reciprocate
30 within the cylinders, each second piston being in mechanical communication with the
cam surface of the second track such that as the cylinders and second track move with
32 respect to each other, the second pistons reciprocate within the cylinders, the pistons
being operable to compress the combustible mixture until the mixture autoignites,
34 without the introduction of a spark.

70. A homogenous charge compression ignition engine comprising:
2 an engine housing;
a plurality of chambers each having a first and a second open end;
4 an intake system operable to introduce a combustible mixture of air and fuel into
each of the chambers; and
6 a first and a second piston movably disposed in each of the cylinders such that a
combustion chamber is defined between the first and second pistons; the pistons being
8 operable to compress the combustible mixture until the mixture autoignites, without the
introduction of a spark.

71. A method of sensing combustion phasing in a homogenous charge
2 compression engine comprising:
providing a knock sensor for producing a signal representing the sound and/or
4 vibration from the engine;

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- 6 correlating the signal from the knock sensor with the combustion phasing of the engine; and
- using the correlated signal to determine the combustion phasing of the engine.